Report 2102

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DAVID TAYLOR MODEL BASIN

WASHINGTON, D.C.

DEPARTMENT OF THE NAVY

HYDROMECHANICS

AERODYNAMICS

STRUCTURAL MECHANICS

APPLIED MATHEMATICS

ACOUSTICS AND VIBRATION

LEADING-EDGE WEDGES TO REDUCE THE DRAG OF THICK WINGS AT SUPERSONIC SPEEDS AND TO INCREASE LIFT AT LOW SPEEDS

by

Richard M. Hartley, Roger J. Furey, and
Robert P. Letendre, Jr.

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AERODYNAMICS LABORATORY

RESEARCH AND DEVELOPMENT REPORT

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Bureau of Naval Weapons
Problem Assignment 1-34-04

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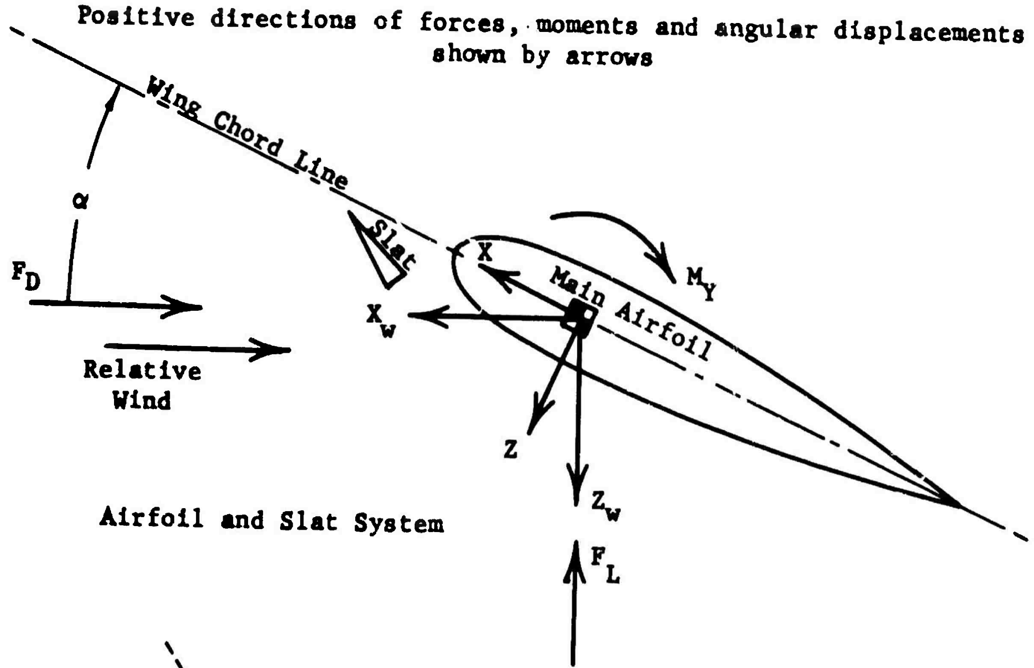
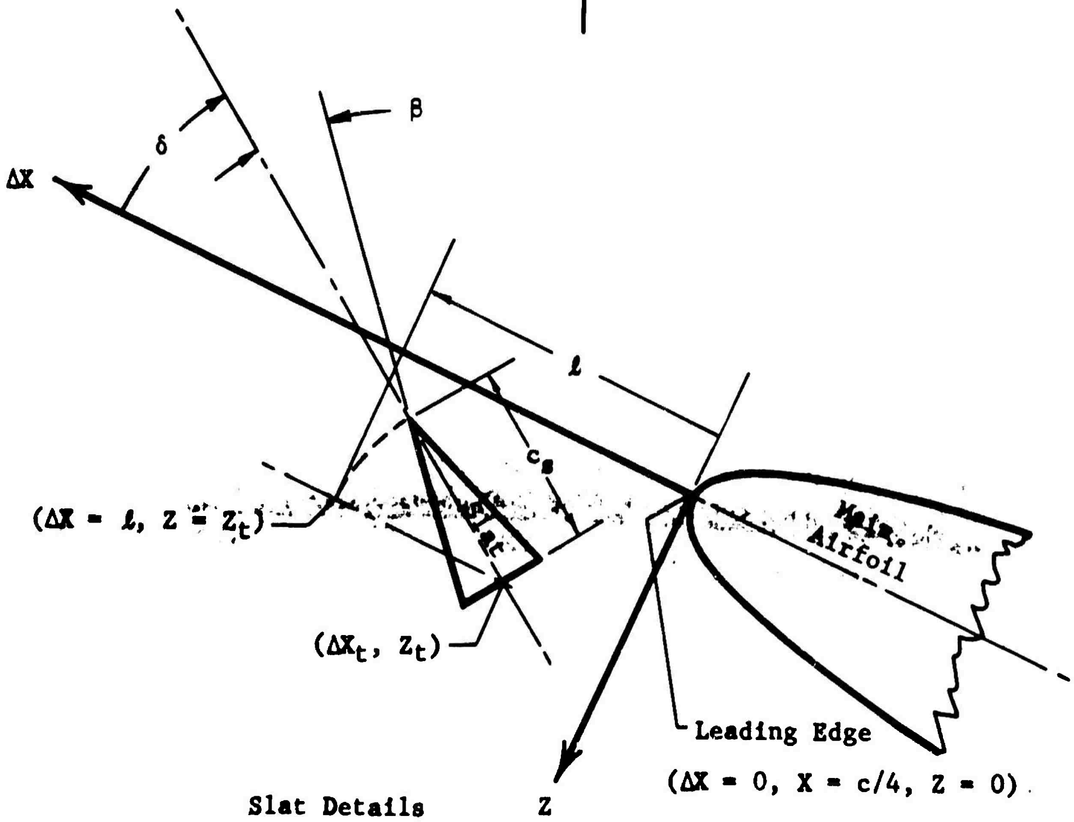
NOTATION

Positive directions of forces, moments and angular displacements are shown by arrows



Airfoil and Slat System



Slat Details

Axis	Force in pounds	Force Coefficient	Moment in pound-feet	Moment Coefficient
X_w	F_D	$C_D = F_D/qS$	--	--
Y	--	--	M_Y	$C_m = M_Y/qSc$
Z_w	F_L	$C_L = F_L/qS$	--	--

SYMBOLS

A	aspect ratio ($b^2/2S$)
a	speed of sound in air
$b/2$	span of panel
c	wing panel chord
c_s	slat chord
ℓ	slat protrusion length (at $\delta = 0^\circ$)
M	Mach number (V/a)
p	free-stream static pressure
q	dynamic pressure ($\gamma p M^2/2$)
R	Reynolds number ($\rho Vc/\mu$)
S	plan area of semispan wing panel
V	airspeed
β	semi-apex angle of wedge or plate
γ	ratio of specific heat at constant pressure to specific heat at constant volume (1.40 for air)
μ	absolute viscosity of air
ρ	mass density of air

Angular Settings

α	angle of attack in degrees (angle between the wing chord plane and the relative-wind vector)
δ	slat deflection angle in degrees (angle between the slat chord plane and the airfoil chord plane)

Subscripts

max	maximum
s	slat
t	trailing edge

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SUMMARY

An unswept 12-percent-thick wing panel (NACA 0012 section) was tested with a wedge protruding from the blunt leading edge to determine if wing drag could be reduced and lift-to-drag ratio improved at a supersonic airspeed (Mach number 1.87). The wing and wedge were also tested at low subsonic airspeeds to determine if a slat effect existed which would increase maximum lift.

At the supersonic airspeed, the wedge reduced the drag of the plain wing by as much as 29 percent at low angles of attack. At higher angles, this drag reduction vanished but the wedge still increased the maximum ratio of lift to drag by as much as 20 percent.

At low speeds, a wedge slat increased maximum lift by as much as 54 percent. A small cambered airfoil slat (with a somewhat larger chord than the wedge) was able to increase maximum lift by 72 percent.

INTRODUCTION

Previous tests (Reference 1) have shown that spikes protruding from the leading edge of a blunt wing can reduce wing drag at supersonic airspeeds. The Bureau of Naval Weapons suggested that two-dimensional devices (wedges) placed in front of blunt leading edges would lower supersonic drag even more than spikes and, in addition, might raise the value of maximum lift attainable at low speeds. These suggestions were incorporated into Problem Assignment 1-34-04 given to the David Taylor Model Basin by the Bureau of Naval Weapons.

A series of wind tunnel tests were conducted with wedge-type devices mounted in front of a thick, low-aspect-ratio, semispan wing model (NACA 0012 section). At supersonic speeds, the wedge devices were positioned mostly in the chord plane of the wing. At subsonic speeds, the wedge devices (or a small auxiliary airfoil) were positioned mostly with their leading edges deflected downward. Pertinent experimental results were informally discussed with cognizant BuWeps personnel on several occasions during and after the tests.

MODELS AND APPARATUS

The twelve-percent-thick wing model was manufactured of aluminum alloy at TMB. It was basically the same model that was used in the leading-edge spike tests of Reference 1. The semispan wing with attached auxiliary wedge was supported at the wind tunnel wall by a cantilever strain-gage wall balance. The arrangement of the wing and balance is shown in Figure 1.

Two balance beams with different stiffnesses were used during the course of the tests. Each beam measured the aerodynamic loads imposed on the wing-slat combination. The strain-gage outputs from a given beam were connected to self-balancing potentiometers and the data were read from those instruments.

One set of wedges was supported in the wing chord plane by three bars which extended back into the wing. The longitudinal position of each wedge could be adjusted in fixed increments. The rearmost position placed the wedge trailing edge flush with the wing leading edge. Provisions were also made to support two thin splitter plates in the wing-chord plane.

Another set of wedges and a small Clark Y airfoil were supported by relatively thick end plates which were attached to the wing. These plates allowed systematic variation of wedge longitudinal position and deflection angle. Sketches of the various wedges, plates, auxiliary airfoil and supports are shown in Figure 1. A photograph of the wing with a Clark Y slat protruding forward is shown in Figure 2.

The 18-Inch Supersonic Wind Tunnel was used for tests at both subsonic and supersonic airspeeds. To obtain subsonic airspeeds, straight test-section liners were used in conjunction with a controllable throttle valve located downstream of the test section. The supersonic airspeed was obtained from a set of fixed converging-diverging Laval-type nozzle blocks.

TESTS

All of the supersonic tests were conducted at a Mach number of 1.87. Most of the subsonic tests were conducted at a Mach number of 0.25 and a few were conducted at a Mach number of 0.30. The significant configurations tested are listed in Tables 1 and 2. These tables also list some of the significant aerodynamic test results. Tests conducted with a flexible balance beam were restricted in angle-of-attack range because of balance load limitations. Most of the tests were conducted with a stiff balance beam, which allowed testing throughout significant ranges of angle of attack.

The stagnation pressure and temperature for the tunnel were approximately atmospheric. The average Reynolds numbers during the test were:

Mach Number	$R \times 10^{-6}$
1.87	2.40
0.30	1.30
0.25	1.10

The dew point of the supply air did not exceed -15° F.

DATA

The recorded strain-gage output data were reduced to coefficient form with desk calculators. Airstream angularity corrections were applied to all the data. Another angular correction was made to account for the fact that the wing chord was not exactly parallel to the balance axial-force direction.

All the subsonic data were corrected for blockage and jet boundary effects using the methods outlined in Reference 2. In addition, the subsonic data were corrected for the loss in dynamic pressure that occurred in that portion of the wing that was submerged in the relatively thick tunnel-wall boundary layer.

The data are considered to be repeatable within the following limits:

Mach Number	C_m	C_L	C_D	α	δ	$\frac{\Delta X_t}{c}$	$\frac{Z_t}{c}$	M
1.87	±0.008	±0.02	±0.004	±0.10°	±1°	±0.0012	±0.0025	±0.01
0.30, 0.25	±0.008	±0.03	±0.010	±0.10°	±1°	±0.0012	±0.0025	±0.01

RESULTS AND DISCUSSION

The data are presented principally as plots of dimensionless coefficients versus angle of attack (or versus angle of attack plus a significant slat parameter). The significant aerodynamic results are also presented in Tables 1 and 2 as functions of model configuration. The axis system and coefficients used in this report are defined in the Notation.

DRAG REDUCTION AT SUPERSONIC SPEEDS

At the supersonic airspeed, the wing drag was reduced by all of the sharp-edged slat-like devices tested, as shown in Figure 3. However, the drag of the wing with a slat rises to the wing-alone value when the angle of attack reaches 10° to 15°. This failure of the devices to reduce the drag at high angles has been noted in other similar devices, such as aerodynamic spikes (see Reference 3).

The ratio of lift to drag (L/D) is probably a more significant quantity than drag alone at supersonic speeds. Wedges placed ahead of the wing leading edge can increase the value of $(L/D)_{max}$ to 3.0 (from 2.3 for the plain wing), as shown in Figure 4a. Deflecting the leading edge of the wedge out of the wing chord plane has no appreciable influence on $(L/D)_{max}$ (Figures 5a and 5b). Deflecting the trailing edge of the backward-facing Clark Y slat similarly changes $(L/D)_{max}$ only slightly (Figure 5c).

LIFT INCREASE AT LOW SUBSONIC SPEEDS

A splitter plate lowers the available maximum lift coefficient of the wing, usually causing a gentle stall, as shown in Figure 6a. Similarly, a wedge in the wing chord plane does not increase $C_{L_{max}}$ of the plain wing (Figure 6b).

The longitudinal characteristics of a typical configuration with a forward-facing Clark Y airfoil are shown together with a plain wing in Figure 7. In general, the Clark Y slat destabilizes the wing, increases the maximum lift considerably, and increases the drag somewhat.

The Clark Y slat can raise the $C_{L_{max}}$ to as high as 1.62, as shown in Figure 8. These curves also show that the lift increase is a function of wing angle of attack and of the deflection angle. Similar curves at different longitudinal and vertical positions (not shown) show that the lift increase also depends on the position of the slat trailing edge. In a similar manner, a downward-deflected wedge can raise the $C_{L_{max}}$ to 1.45, as shown in Figure 9.

The contours of Figure 10 summarize the maximum lift performance of the slat-like devices. The curves show that the maximum value of $C_{L_{max}}$ occurs with the Clark Y trailing edge 3.75 percent chord above the wing chord plane, 1.25 percent chord ahead of the wing leading edge and with a deflection angle of -50°. The large magnitude of the slat deflection and the large wing angle of attack necessary to obtain maximum lift would be less for a higher aspect ratio wing.

It should be noted that the reference area for the coefficients was always the planform area of the clean wing panel. When a slat is added, some of the increase in $C_{L_{max}}$ is caused by the increase in plan area. However, most of the $C_{L_{max}}$ increase is caused by the improved flow conditions on the upper surface of the wing. This is indicated by increments of $C_{L_{max}}$ that are much larger than the 14.2 percent plan area increase caused by the largest slat.

Aerodynamics Laboratory
David Taylor Model Basin
Washington, D. C.
August 1965

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2. Pope, Alan. Wind-Tunnel Testing. 2d. ed. N.Y., Wiley, 1954. 511 p. illus.

3. Brindle, Clayton Carl, and Michael J. Malia, Jr. Longitudinal Aerodynamic and Heat-Transfer Characteristics of a Hemisphere-Cylinder Missile Configuration With an Aerodynamic Spike. Wash., Jul 1963. 30 l. incl. illus. (David Taylor Model Basin. Aero Rpt. 1061)

Table 1

Significant Supersonic Lift and Drag Characteristics of a Thick Wing With Various Configurations of Front-Mounted Slat Devices (Mach Number 1.87)

Slat			Position				Aerodynamic Characteristics		
Type	$\left(\frac{c_s}{c}\right)$	β in deg	$\left(\frac{\ell}{c}\right)$	$\left(\frac{\Delta X_t}{c}\right)$	$\left(\frac{\Delta Z_t}{c}\right)$	δ in deg	$C_{D_{min}}$	$\frac{L}{D}$ max	$\alpha\ \frac{L}{D}$ max
—	—	—	0	0	0	—	0.097	2.32	12.0
Plate	—	10	0.05	0	0	0	0.086	2.32	12.0
			0.10				0.064		
			0.15				0.052		
			0.20				0.053		
			0.25				0.054		
Wedge (With Bar Support)	0.10	9	0.10	0	0	0	0.068	3.04	10.0
			0.15	0.050			0.059	3.00	10.0
			0.20	0.100			0.057	2.91	12.0
			0.25	0.150			0.055	2.82	10.0
Wedge	0.10	6	0.10	0	0	0	0.087	2.56	10.0
				0		3	0.086	2.79	12.0
				0.001		6	0.086	2.84	14.0
				0.002		12	0.096	2.85	14.0
				0.005		18	0.109	2.71	16.0
				0.009		24	0.125	2.27	20.0
Wedge	0.10	6	0.15	0.050	0	0	0.076	2.71	12.0
				0.050		3	0.076	2.60	10.0
				0.051		6	0.081	2.74	12.0
				0.051		9	0.091	2.59	14.0
Wedge	0.15	6	0.15	0	0	0	0.079	2.73	-11.5
			0.15	0		6	0.081	2.82	-11.5
			0.175	0.025		0	0.074	2.60	-11.5
			0.175	0.025		6	0.079	2.55	-11.5
			0.20	0.050		0	0.073	2.58	12.5
			0.20	0.050		3	0.085	2.53	8.5
			0.20	0.050		6	0.078	2.61	-11.5
			0.25	0.100		0	0.070	2.62	8.5
			0.25	0.100		3	0.085	2.47	8.5
			0.25	0.100		6	0.081	2.62	-11.5
Clark Y (Backward)	0.15	—	0.16	0.010	0	0	0.076	2.61	12.5
			0.16	0.010		-3	0.077	2.59	-11.5
			0.16	0.011		-6	0.086	2.54	-11.5
			0.21	0.060		0	0.072	2.56	-11.8
			0.21	0.060		-3	0.077	2.59	-11.8
			0.21	0.061		-6	0.078	2.75	-11.8
			0.26	0.110		0	0.073	2.49	-11.8
			0.26	0.110		-3	0.076	2.56	-11.8
			0.26	0.111		-6	0.079	2.63	-11.8

Table 2

Low-Speed Maximum Lift Characteristics of a Thick Wing With Various Configurations of Front-Mounted Slat Devices (Mach number 0.25 unless noted.)

Slat			Position				Aerodynamic Characteristics	
Type	$\left(\frac{c_s}{c}\right)$	β in deg	$\left(\frac{\ell}{c}\right)$	$\left(\frac{\Delta X_t}{c}\right)$	$\left(\frac{\Delta Z_t}{c}\right)$	δ in deg	$C_{L_{max}}$	$[\alpha]C_{L_{max}}$ in deg
—	—	—	0	—	—	—	0.94	23.8
Plate*	—	10	0.050 0.100 0.150 0.200	—	—	0	0.63 0.67 0.71 0.81	19.0 21.4 19.2 21.5
Wedge*	0.10	6	0.100 0.150 0.200 0.250	0 0.050 0.100 0.150	0	0	0.64 0.57 0.67 0.72	13.5 19.2 20.4 22.3
Wedge	0.10	6	0.125 0.125	0.026 0.026	-0.050 -0.050	-25 -30	1.40 1.42	24.4 28.2
Wedge	0.10	6	0.100	0.001 0.001 0.001 0.002 0.002 0.003 0.004	-0.062	-20 -25 -30 -35 -40 -45 -50	0.84 1.02 1.17 1.33 1.45 1.07 1.03	19.3 22.6 24.6 28.1 31.0 30.6 38.6
Wedge	0.10	6	0.100	0.001 0.001 0.002 0.002 0.003	-0.050	-25 -30 -35 -40 -45	0.98 1.06 1.27 1.30 1.17	21.0 22.5 28.5 28.3 28.6
Wedge	0.15	6	0.150	0.013	-0.062	-40	1.41	32.3
Clark Y	0.15	—	0.250	0.106 0.110 0.114 0.119 0.125 0.131	-0.075	-20 -25 -30 -35 -40 -45	1.21 1.30 1.24 1.19 1.05 1.10	29.0 27.9 31.0 29.0 32.5 55.0
Clark Y	0.15	—	0.250	0.106 0.110 0.114 0.119 0.125 0.131	-0.050	-20 -25 -30 -35 -40 -45	1.21 1.25 1.35 1.19 0.96 1.14	29.0 29.0 30.0 20.7 29.5 56.0

*These configurations tested at Mach number 0.30.

Table 2 (Continued)

Slat			Position				Aerodynamic Characteristics	
Type	$\left(\frac{c_s}{c}\right)$	β in deg	$\left(\frac{\ell}{c}\right)$	$\left(\frac{\Delta X_t}{c}\right)$	$\left(\frac{\Delta Z_t}{c}\right)$	δ in deg	$C_{L_{max}}$	$[\alpha]C_{L_{max}}$ in deg
Clark Y	0.15	—	0.250	0.106	-0.025	-20	1.06	25.4
				0.110		-25	1.24	28.0
				0.114		-30	1.28	29.8
				0.119		-35	1.16	27.6
				0.125		-40	0.96	29.5
				0.131		-45	1.08	51.6
Clark Y	0.15	—	0.225	0.081	-0.075	-20	1.12	26.6
				0.085		-25	1.15	27.0
				0.089		-30	1.33	29.8
				0.094		-35	1.25	32.0
				0.100		-40	1.14	34.8
				0.106		-45	1.06	49.5
Clark Y	0.15	—	0.225	0.085	-0.050	-25	1.24	29.0
				0.089		-30	1.32	29.8
				0.094		-35	1.28	29.8
				0.100		-40	1.03	27.5
				0.106		-45	1.12	55.0
Clark Y	0.15	—	0.225	0.081	-0.025	-20	1.12	26.0
				0.085		-25	1.18	27.5
				0.089		-30	1.35	26.1
				0.094		-35	1.24	29.0
				0.100		-40	1.14	27.6
				0.106		-45	1.11	56.0
Clark Y	0.15	—	0.200	0.060	-0.075	-25	1.26	29.0
				0.064		-30	1.29	31.5
				0.069		-35	1.36	31.5
				0.075		-40	1.24	29.4
Clark Y	0.15	—	0.200	0.060	-0.050	-25	1.25	29.4
				0.064		-30	1.27	29.5
				0.069		-35	1.38	31.6
				0.075		-40	1.23	29.2
Clark Y	0.15	—	0.200	0.064	-0.025	-30	1.28	29.7
				0.069		-35	1.36	32.0
				0.075		-40	1.25	29.8
				0.081		-45	0.91	29.1
Clark Y	0.15	—	0.175	0.031	-0.075	-20	1.24	31.5
				0.035		-25	1.38	35.9
				0.039		-30	1.34	31.6
				0.044		-35	1.35	31.6
				0.050		-40	1.20	29.4
				0.056		-45	0.97	47.0

Table 2 (Continued)

Slat			Position				Aerodynamic Characteristics	
Type	$\left(\frac{c_s}{c}\right)$	β in deg	$\left(\frac{\ell}{c}\right)$	$\left(\frac{\Delta X_t}{c}\right)$	$\left(\frac{\Delta Z_t}{c}\right)$	δ in deg	$C_{L_{max}}$	$[\alpha]C_{L_{max}}$ in deg
Clark Y	0.15	–	0.175	0.035 0.039 0.044 0.050	-0.050	-25 -30 -35 -40	1.34 1.41 1.46 1.49	35.6 33.8 33.6 34.5
Clark Y	0.15	–	0.175	0.039 0.044 0.050 0.056	-0.025	-30 -35 -40 -45	1.24 1.38 1.45 1.46	29.9 32.2 34.3 34.0
Clark Y	0.15	–	0.175	0.039 0.044 0.050 0.056 0.062	-0.012	-30 -35 -40 -45 -50	0.99 1.05 – 1.27 1.22	23.4 24.5 – 31.0 35.7
Clark Y	0.15	–	0.150	0.006 0.010 0.014 0.019 0.025	-0.075	-20 -25 -30 -35 -40	1.16 1.32 1.44 1.43 1.38	29.6 33.6 36.1 34.0 33.0
Clark Y	0.15	–	0.150	0.014 0.019 0.025 0.030 0.035	-0.062	-30 -35 -40 -44 -48	1.30 1.45 1.51 1.23 0.84	28.6 31.6 33.5 30.1 48.8
Clark Y	0.15	–	0.150	0.010 0.014 0.019 0.025 0.030 0.035 0.038 0.045	-0.050	-25 -30 -35 -40 -44 -48 -50 -55	1.18 1.28 1.41 1.48 1.52 1.56 1.09 0.85	36.0 31.2 34.2 34.0 38.4 38.5 31.7 29.2
Clark Y	0.15	–	0.150	0.019 0.025 0.031 0.038	-0.038	-35 -40 -45 -50	1.35 1.47 1.48 1.14	34.2 36.3 35.4 29.7
Clark Y	0.15	–	0.150	0.014 0.019 0.025 0.031 0.038	-0.025	-30 -35 -40 -45 -50	1.18 1.33 1.48 1.51 1.45	22.6 33.0 35.2 37.5 36.3

Table 2 (Concluded)

Slat			Position				Aerodynamic Characteristics	
Type	$\frac{c_s}{c}$	β in deg	$\left(\frac{\ell}{c}\right)$	$\left(\frac{\Delta X_t}{c}\right)$	$\left(\frac{\Delta Z_t}{c}\right)$	δ in deg	$C_{L_{max}}$	$[\alpha]C_{L_{max}}$ in deg
Clark Y	0.15	–	0.150	0.014	-0.012	-30	1.15	27.6
				0.019		-35	1.26	32.0
				0.025		-40	1.43	35.6
				0.031		-45	1.55	38.4
				0.038		-50	1.47	37.0
				0.045		-55	1.12	29.5
Clark Y	0.15	–	0.125	-0.011	-0.062	-30	1.23	32.9
				-0.006		-35	1.33	32.5
				0		-40	1.45	36.2
				0.006		-45	1.31	38.0
Clark Y	0.15	–	0.125	-0.011	-0.050	-30	1.11	27.5
				-0.006		-35	1.28	32.0
				0		-40	1.33	31.5
				0.006		-45	1.56	39.7
				0.012		-50	1.31	38.0
				0.020		-55	1.11	37.4
Clark Y	0.15	–	0.125	-0.011	-0.038	-30	1.06	25.5
				-0.006		-35	1.28	29.9
				0		-40	1.37	34.2
				0.006		-45	1.50	38.5
				0.012		-50	1.62	40.4
				0.016		-55	1.14	35.4
Clark Y	0.15	–	0.100	-0.040	-0.062	-25	0.97	21.0
				-0.036		-30	1.08	23.0
				-0.031		-35	1.22	27.5
				-0.025		-40	1.08	27.1

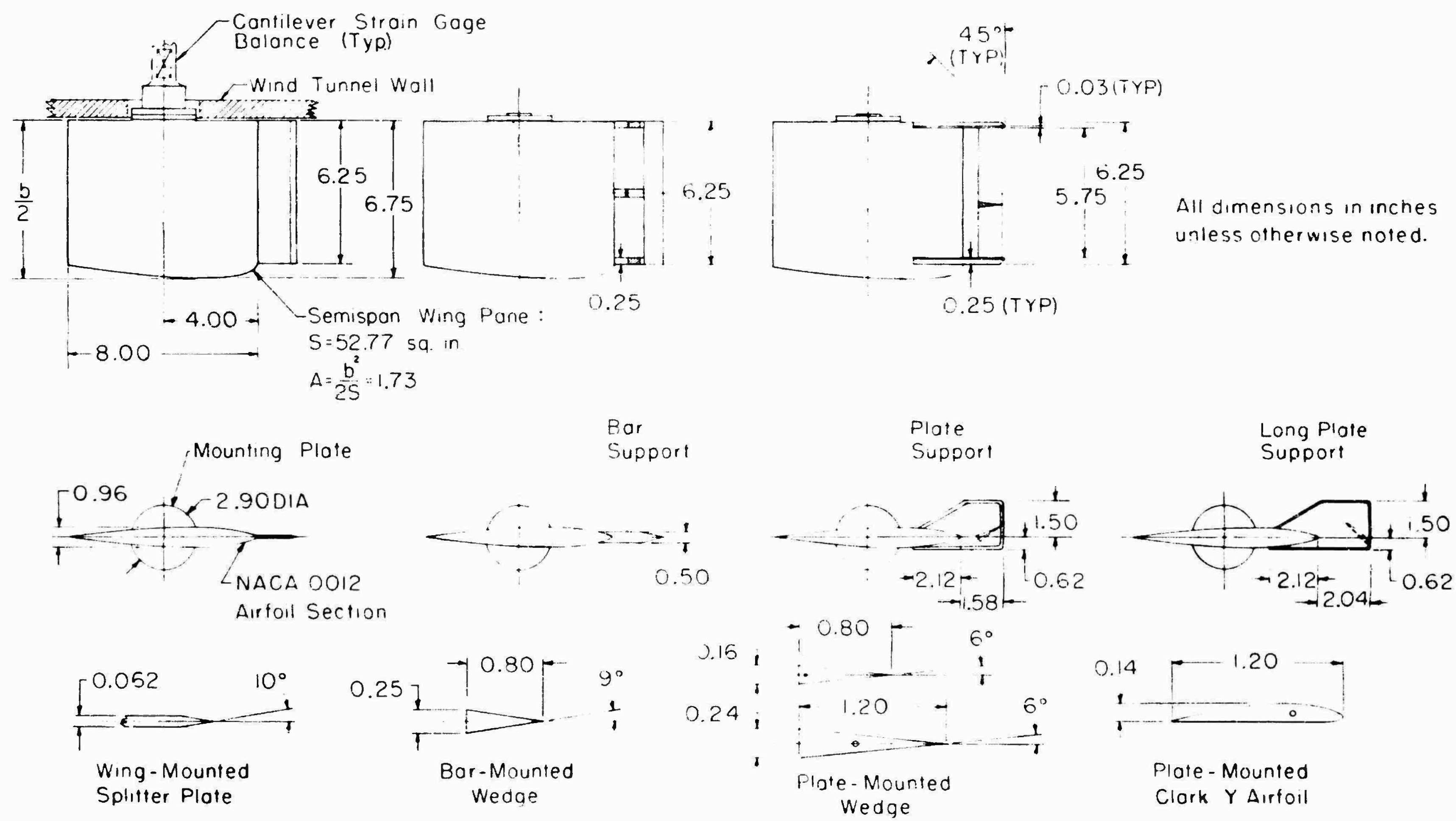

Figure 1-Arrangement of Semispan Wing Panel and Various Slat-Type Devices

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Figure 2 - Photograph of Thick Semispan Wing Model and Clark Y Slats in the 18-Inch Supersonic Wind Tunnel Test Section (Clark Y trailing edge is pointed forward.)

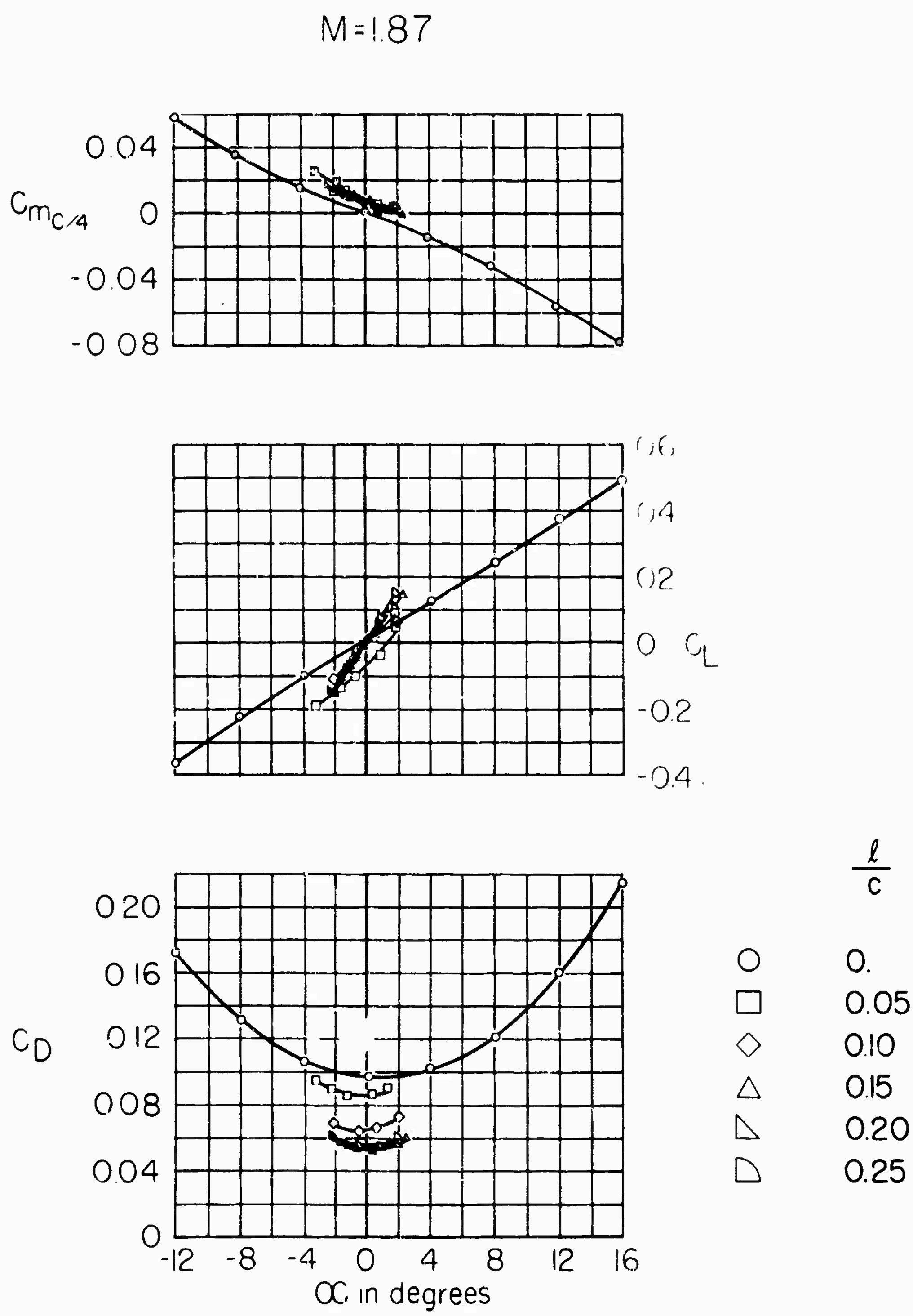


Figure 3 - Supersonic Longitudinal Characteristics of a Thick Wing With Drag-Reducing Devices in the Chord Plane

(a) Splitter Plate; β = 10°

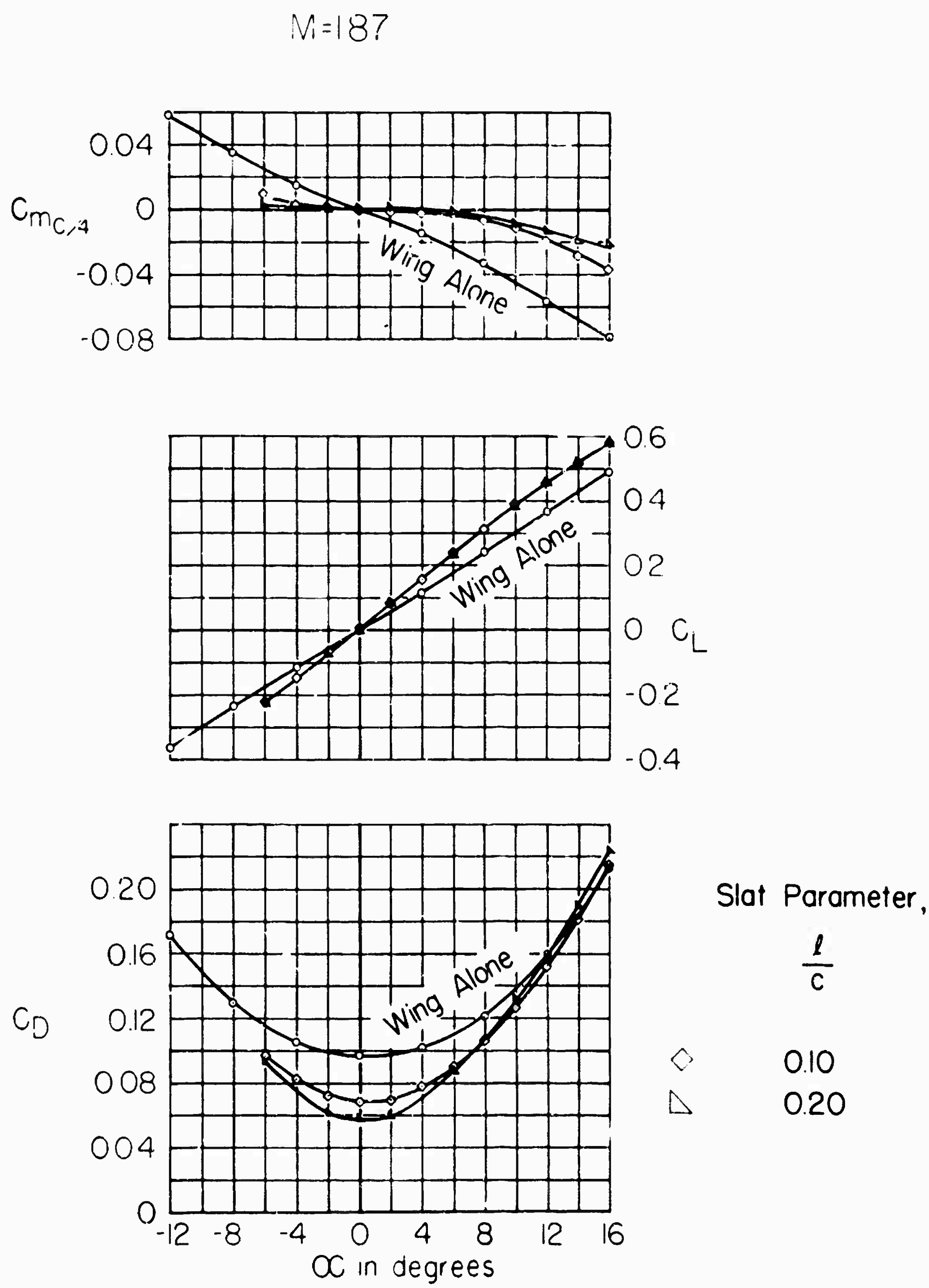


Figure 3 (Continued)

(b) Wedge With Bar Support; $(c_s/c) = 0.10$; $\beta = 9°$; $\delta = 0°$

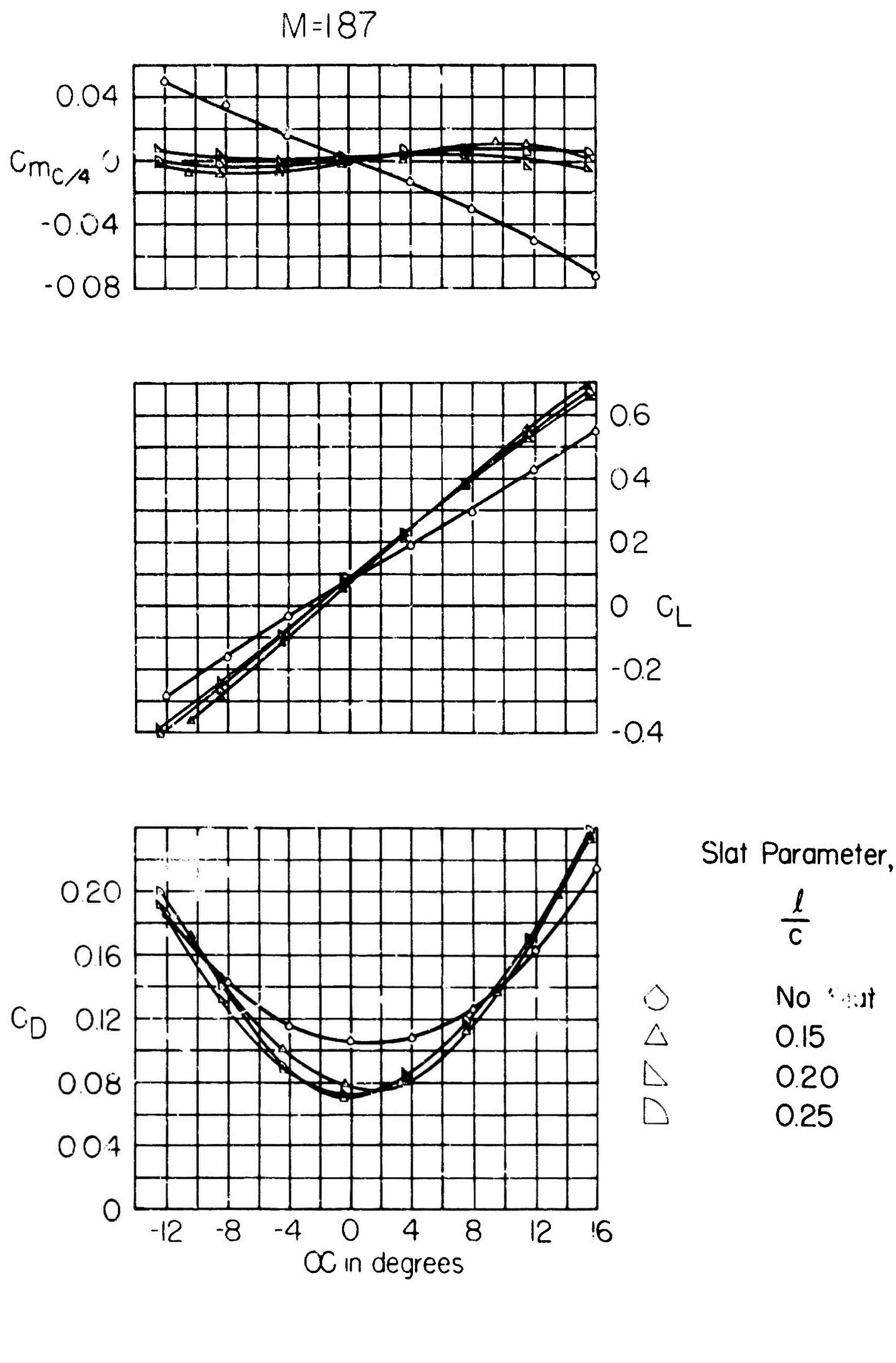


Figure 3 (Continued)

(c) Wedge With Long Plate Support; $(c_s/c) = 0.15$; $\beta = 6°$; $\delta = 0°$

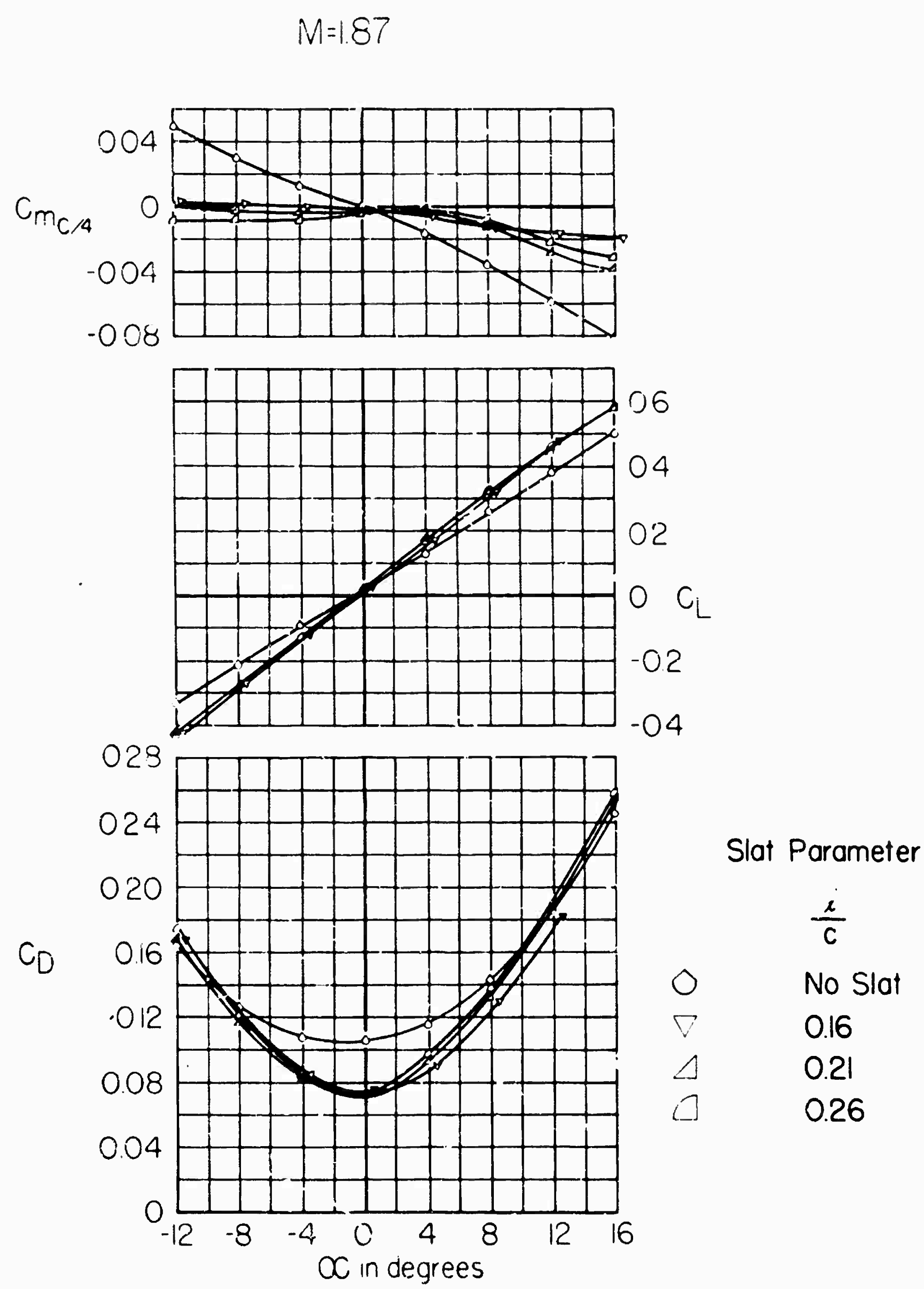


Figure 3 (Concluded)

(d) Clark Y With Long Plate Support; $(c_s/c) = 0.15$; $\delta = 0°$

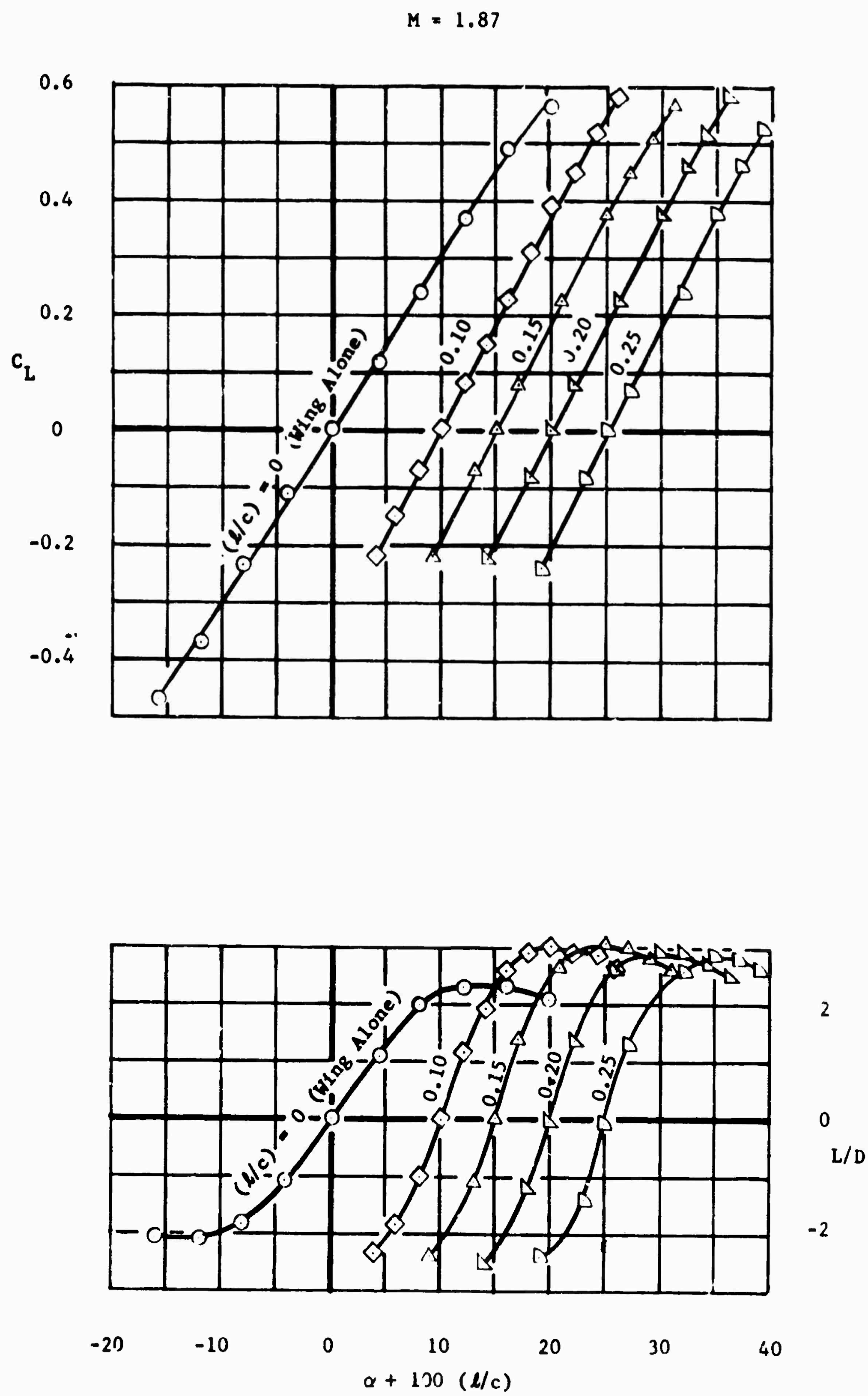


Figure 4 - Influence of Slat Longitudinal Position on the Supersonic Lift-To-Drag Ratio Characteristics of a Thick Wing

(a) Wedge With Bar Support. $c_s/c = 0.10$; $\beta = 9°$; $\delta = 0°$

M = 1.87

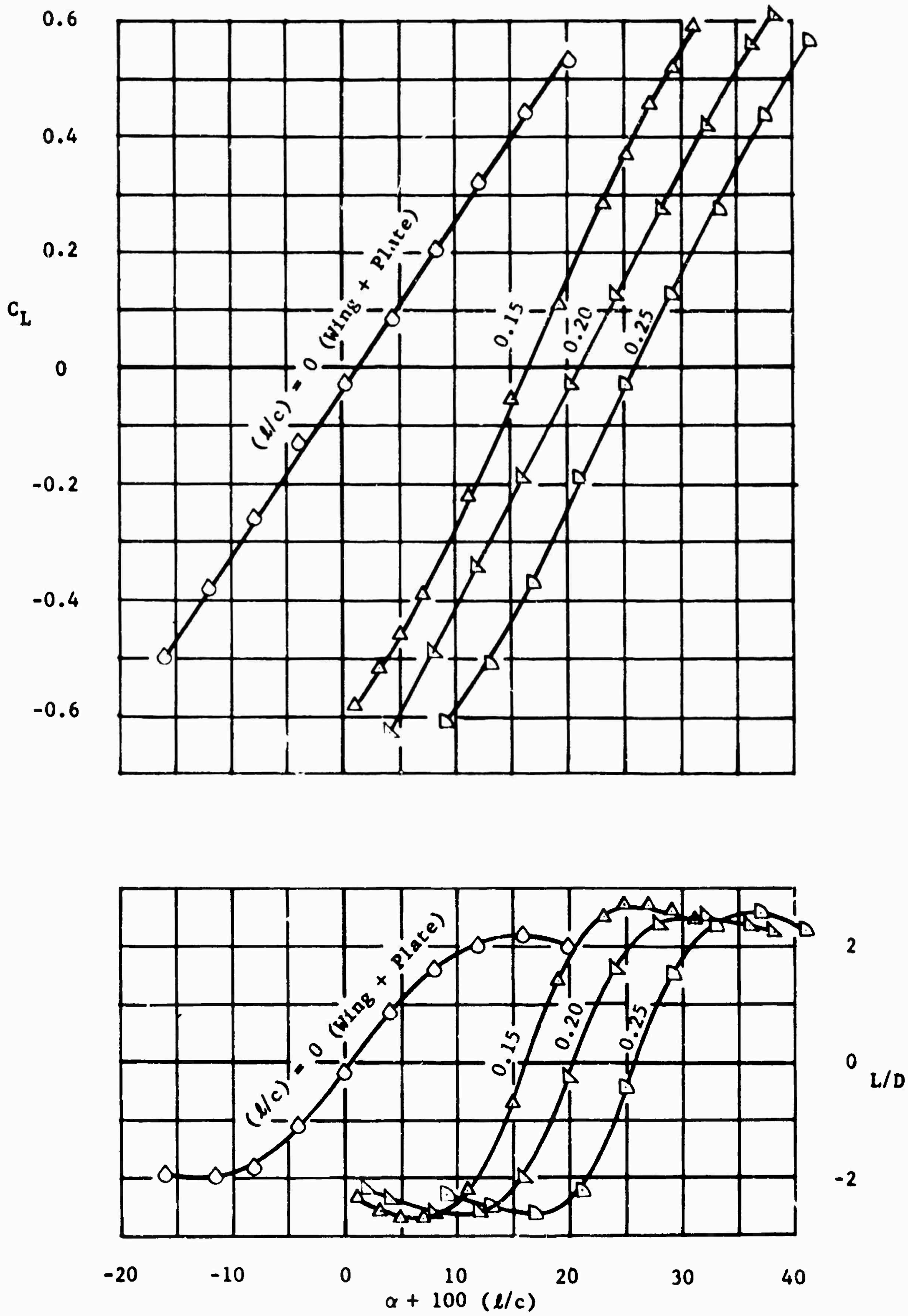


Figure 4 (Continued)

(b) Wedge With Long Plate Support. $c_s/c = 0.15$;
$\beta = 6^\circ$; $\delta = 0^\circ$

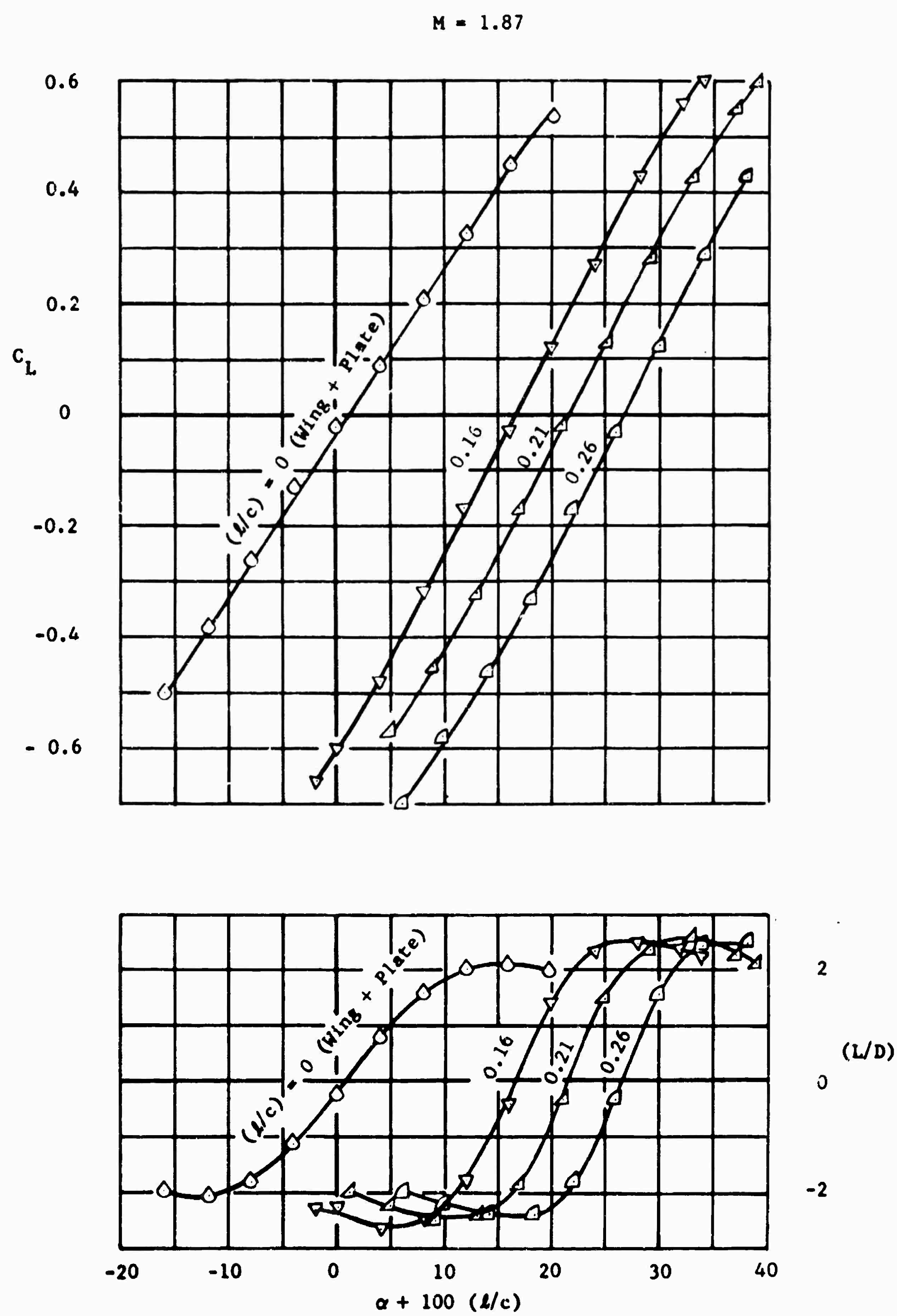


Figure 4 (Concluded)

(c) Clark Y With Long Plate Support. $c_s/c = 0.15$; $\delta = 0^\circ$

(Clark Y trailing edge is pointed forward.)

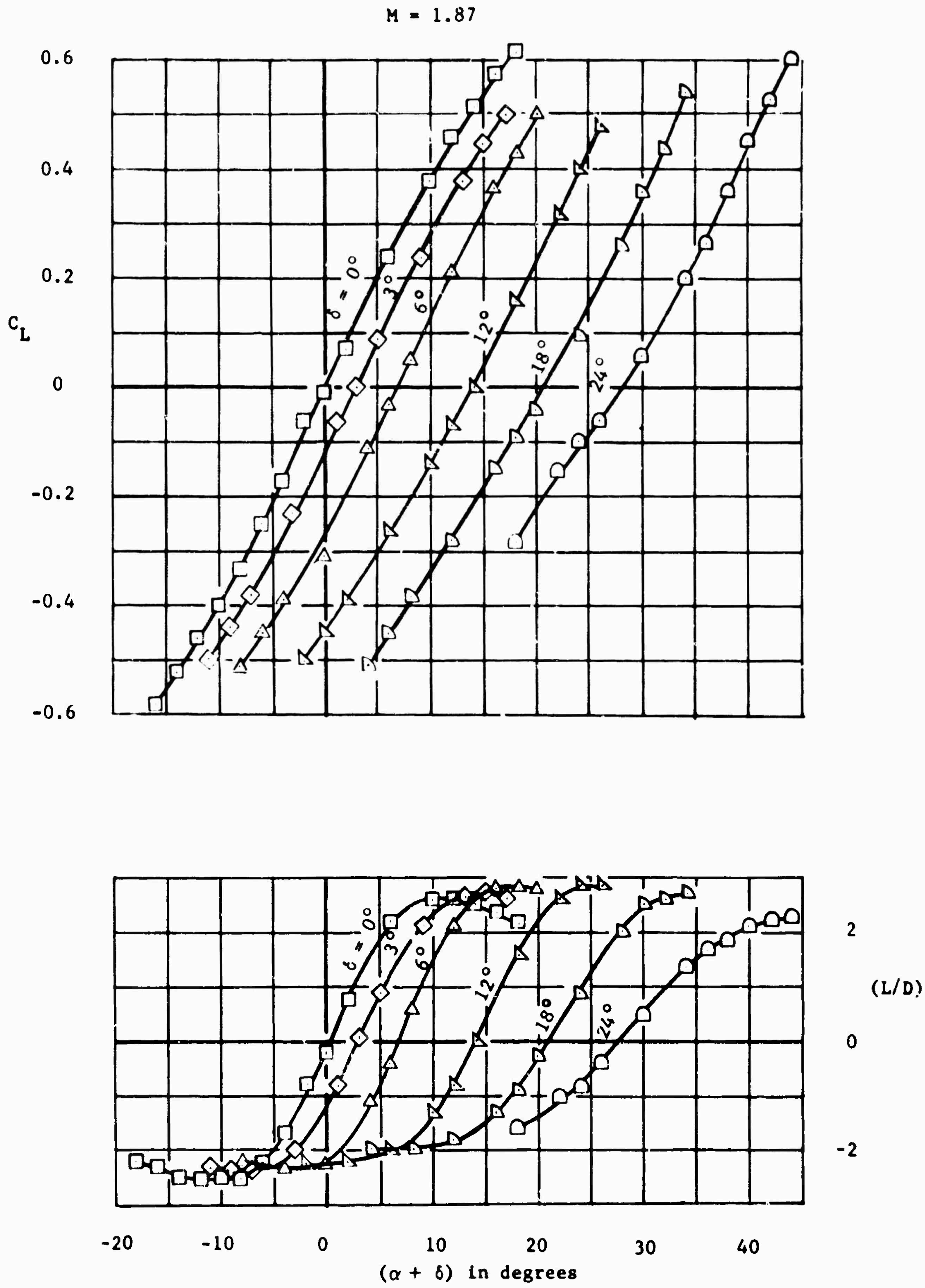


Figure 5 - Influence of Slat Deflection Angle on the Supersonic Lift-To-Drag Ratio Characteristics of a Thick Wing

(a) Wedge With Plate Support. $c_s/c = 0.10$; $\beta = 6^\circ$; $\ell/c = 0.10$

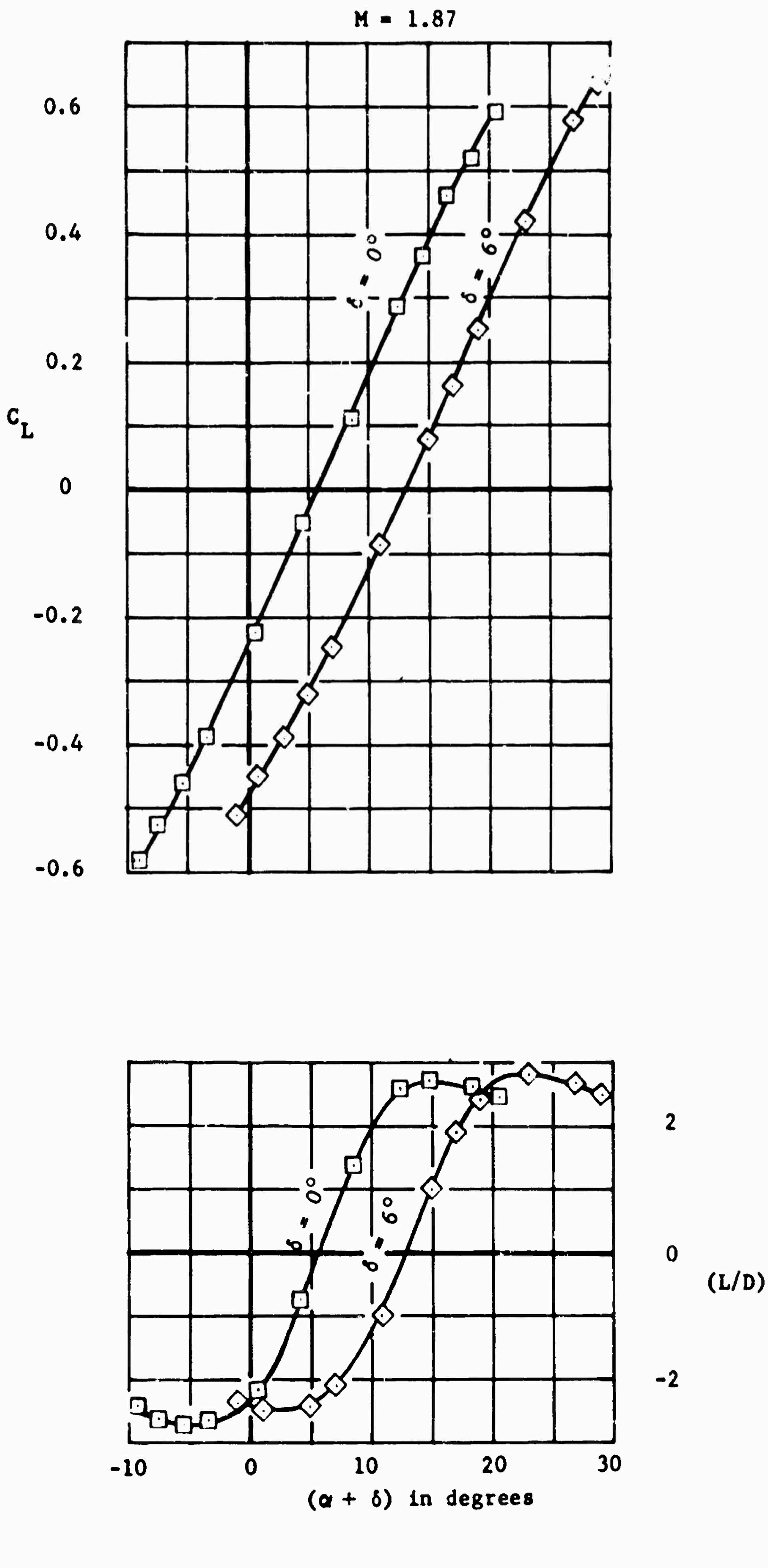


Figure 5 (Continued)

(b) Wedge With Long Plate Support. $c_s/c = 0.15$; $\beta = 6^\circ$; $\ell/c = 0.15$

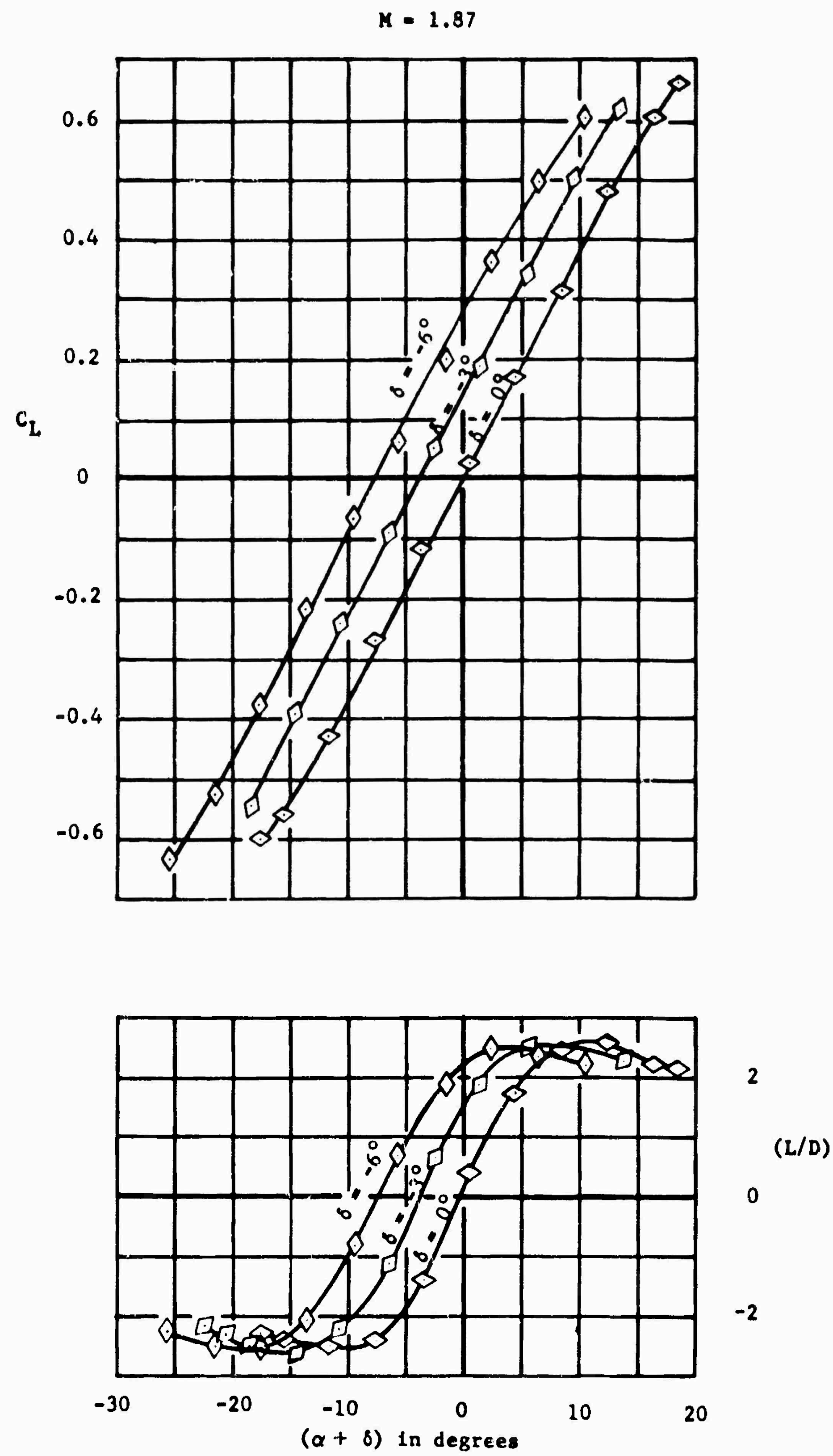
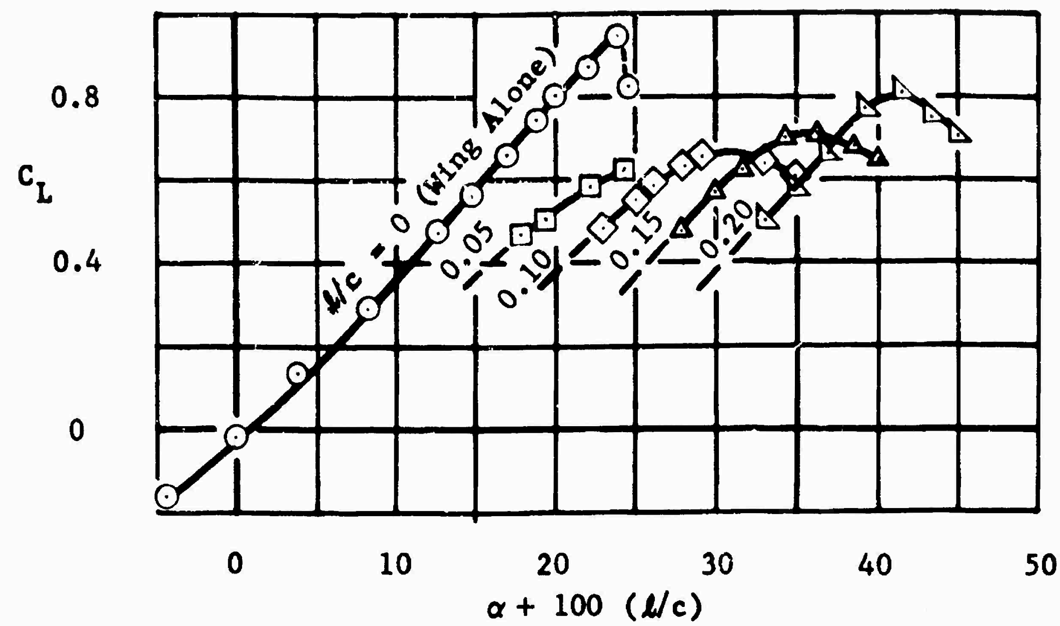


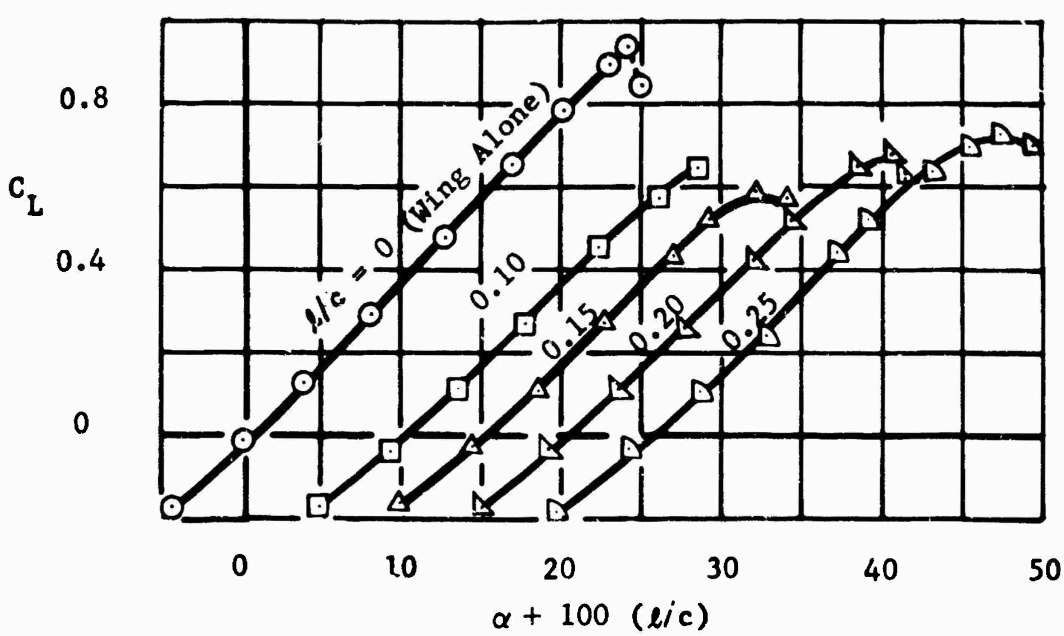
Figure 5 (Concluded)

(c) Clark Y With Long Plate Support. $c_s/c = 0.15$; $\ell/c = 0.15$

(Clark Y trailing edge is pointed forward.)



(a) Splitter Plate, $\beta = 10°$



(b) Wedge With Bar Support . $c_s/c = 0.10$; $\beta = 6°$

Figure 6 - Low-Speed Lift Characteristics of a Thick Wing With Sharp-Edged Slat Devices in the Chord Plane. $M = 0.30$; $\delta = 0°$

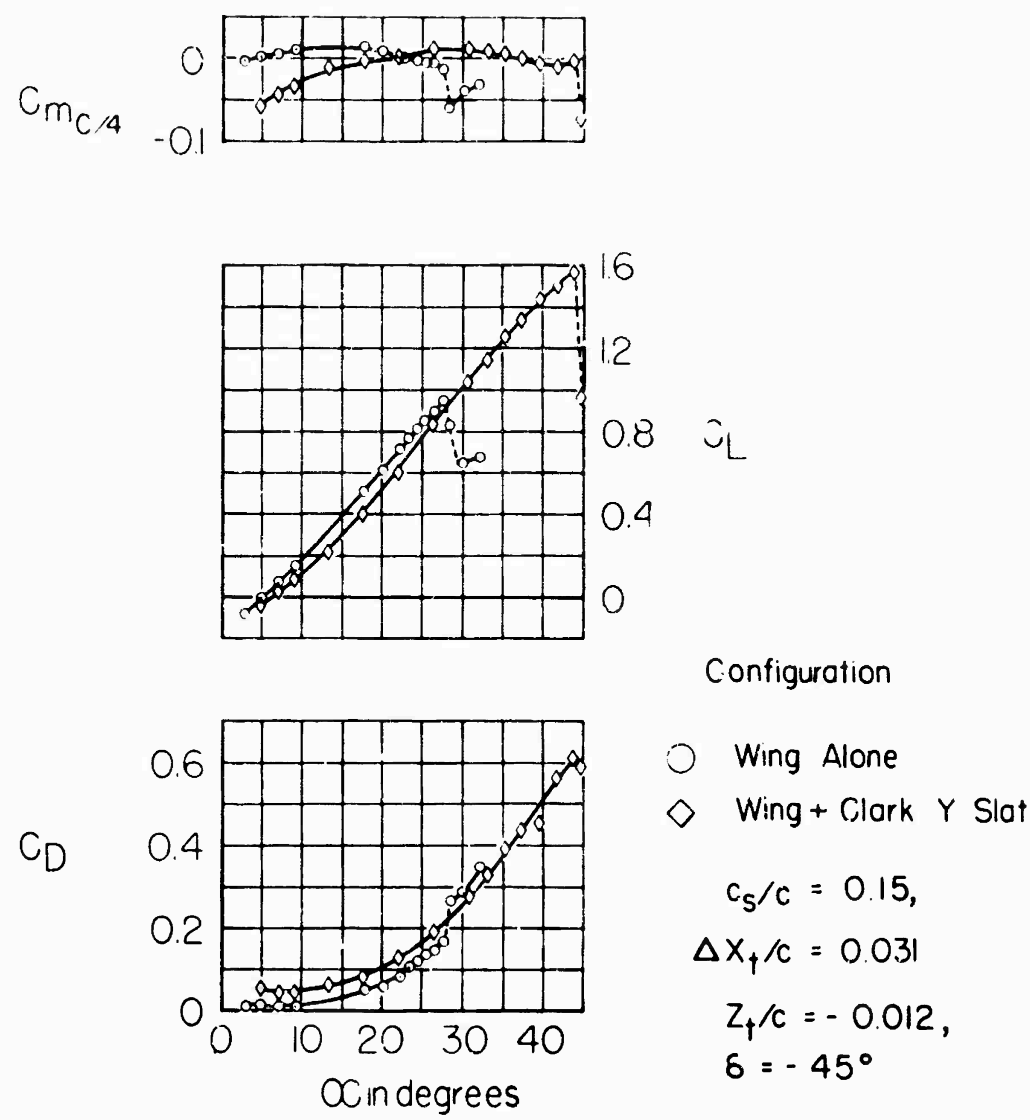


Figure 7 - Typical Low-Speed Longitudinal Characteristics of a Thick Wing With a Forward-Facing Clark Y Slat (M = 0.30)

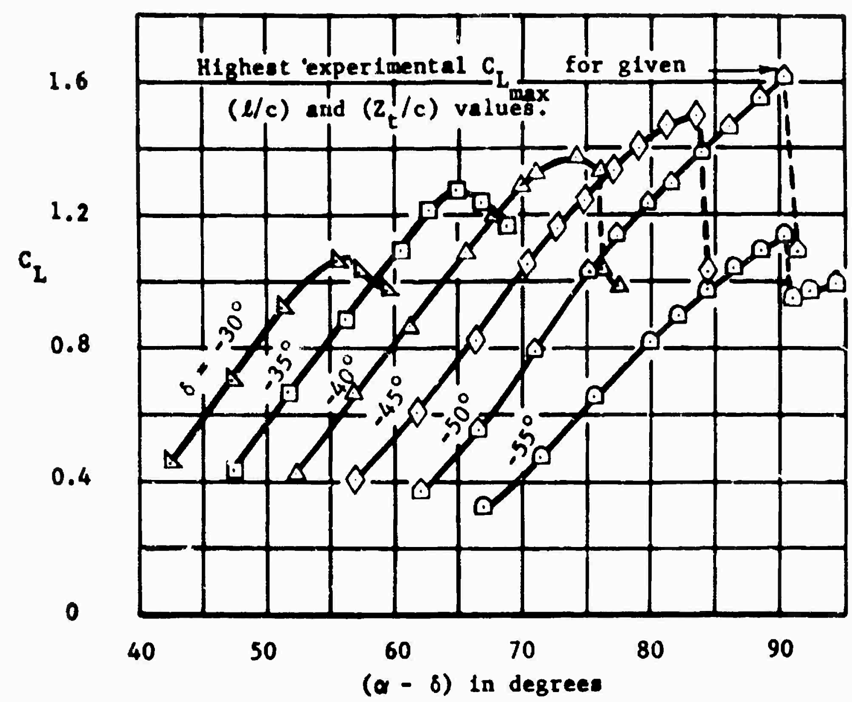


Figure 8 - Typical Low-Speed Lift Characteristics of a Thick Wing With a Deflected Clark Y Slat. M = 0.25; Long Plate Support; c_s/c = 0.15; ℓ/c = 0.125; Z_t/c = -0.038

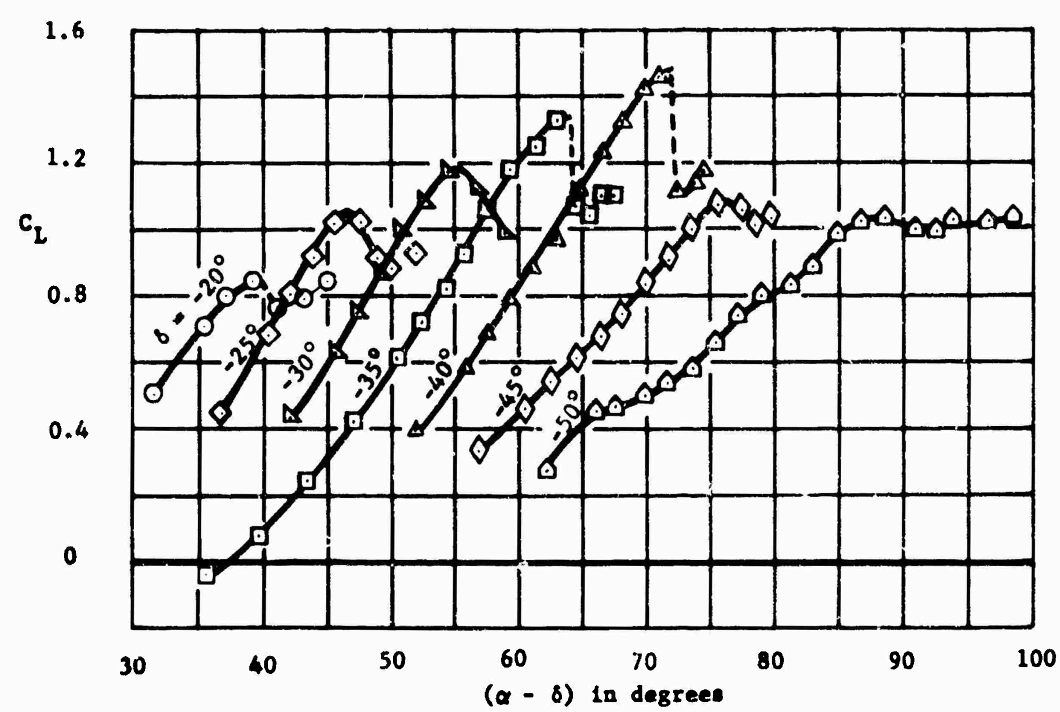


Figure 9 - Typical Low-Speed Lift Characteristics of a Thick Wing With a Deflected Wedge Slat. M = 0.25; Plate Support; β = 6°; ℓ/c = 0.100; Z_t/c = 0.062

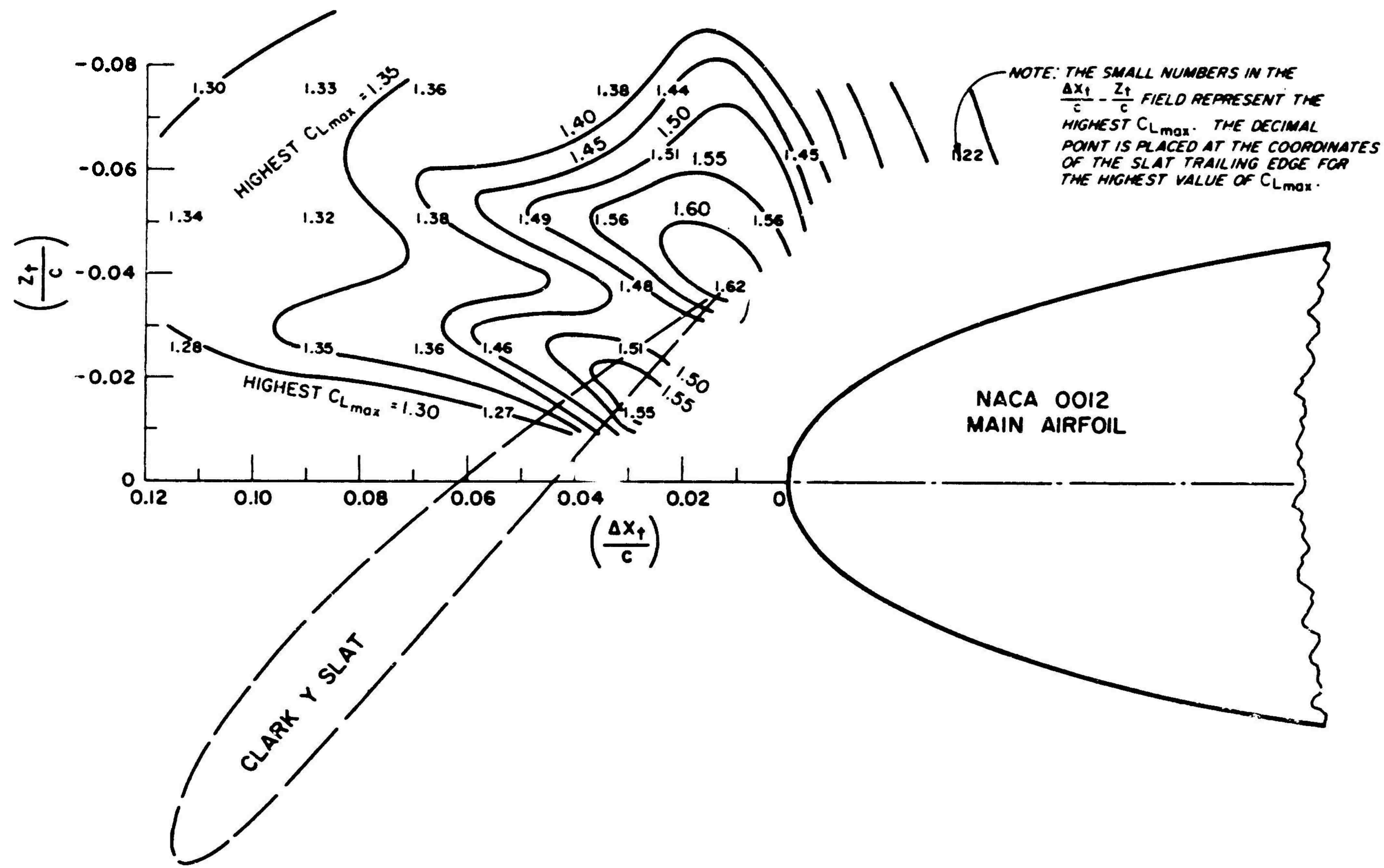


Figure 10 – Contours of Maximum Lift Coefficients Obtained from Tests of a Clark Y Slat Mounted in Front of a Thick Wing (M = 0.25)

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5 AUTHOR(S) (Last name, first name, initial) Hartley, Richard M., Furey, Roger J., and Letendre, Robert P. Jr.	

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13 ABSTRACT

An unswept 12-percent-thick wing panel (NACA 0012 section) was tested with a wedge protruding from the blunt leading edge to determine if wing drag could be reduced and lift-to-drag ratio improved at a supersonic airspeed (Mach number 1.87). The wing and wedge were also tested at low subsonic airspeeds to determine if a slat effect existed which would increase maximum lift.

At the supersonic airspeed, the wedge reduced the drag of the plain wing by as much as 29 percent at low angles of attack. At higher angles, this drag reduction vanished but the wedge still increased the maximum ratio of lift to drag by as much as 20 percent.

At low speeds, a wedge slat increased maximum lift by as much as 54 percent. A small cambered airfoil slat (with a somewhat larger chord than the wedge) was able to increase maximum lift by 72 percent.

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Supersonic Thick-Wing Drag						
Supersonic Wing Lift-To-Drag Ratio						
Supersonic Drag Reduction						
Low-Speed Maximum Lift						
Low-Speed Lift Augmentation						
Slats						
Auxiliary Airfoil						
NACA 0012 Airfoil						
Clark Y Airfoil						

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ERRATA

for

David Taylor Model Basin Report 2102

Aerodynamics Laboratory Report 1094

Dated

August 1965

Please substitute the attached pages 7, 16, 22, and 25 for the respective pages in the above report.

Table 1

Significant Supersonic Lift and Drag Characteristics of a Thick Wing With Various Configurations of Front-Mounted Slat Devices (Mach Number 1.87)

Slat			Position				Aerodynamic Characteristics		
Type	$\left(\frac{c_s}{c}\right)$	β in deg	$\left(\frac{\ell}{c}\right)$	$\left(\frac{\Delta X_t}{c}\right)$	$\left(\frac{\Delta Z_t}{c}\right)$	δ in deg	$C_{D_{min}}$	$\left\lvert\frac{L}{D}\right\rvert_{max}$	$\alpha\ \frac{L}{D}\ max$
–	–	–	0	0	0	–	0.097	2.32	12.0
Plate	–	10	0.05 0.10 0.15 0.20 0.25	0	0	0	0.086 0.064 0.052 0.053 0.054	2.32	12.0
Wedge (With Bar Support)	0.10	9	0.10 0.15 0.20 0.25	0 0.050 0.100 0.150	0	0	0.068 0.059 0.057 0.055	3.04 3.00 2.91 2.82	10.0 10.0 12.0 10.0
Wedge	0.10	6	0.10	0 0 0.001 0.002 0.005 0.009	0	0 3 6 12 18 24	0.087 0.086 0.086 0.096 0.109 0.125	2.56 2.79 2.84 2.85 2.71 2.27	10.0 12.0 14.0 14.0 16.0 20.0
Wedge	0.10	6	0.15	0.050 0.050 0.051 0.051	0	0 3 6 9	0.076 0.076 0.081 0.091	2.71 2.60 2.74 2.59	12.0 10.0 12.0 14.0
Wedge	0.15	6	0.15 0.15 0.175 0.175 0.20 0.20 0.20 0.25 0.25 0.25	0 0 0.025 0.025 0.050 0.050 0.050 0.100 0.100 0.100	0	0 6 0 6 0 3 6 0 3 6	0.079 0.081 0.074 0.079 0.073 0.085 0.078 0.070 0.085 0.081	2.73 2.82 2.60 2.55 2.58 2.53 2.61 2.62 2.47 2.62	-11.5 -11.5 -11.5 -11.5 12.5 8.5 -11.5 8.5 8.5 -11.5
Clark Y (Backward)	0.15	–	0.16 0.16 0.16 0.21 0.21 0.21 0.26 0.26 0.26	0.010 0.010 0.011 0.060 0.060 0.061 0.110 0.110 0.111	0	0 -3 -6 0 -3 -6 0 -3 -6	0.076 0.077 0.086 0.072 0.077 0.078 0.073 0.076 0.079	2.61 2.59 2.54 2.56 2.59 2.75 2.49 2.56 2.63	12.5 -11.5 -11.5 -11.8 -11.8 -11.8 -11.8 -11.8 -11.8

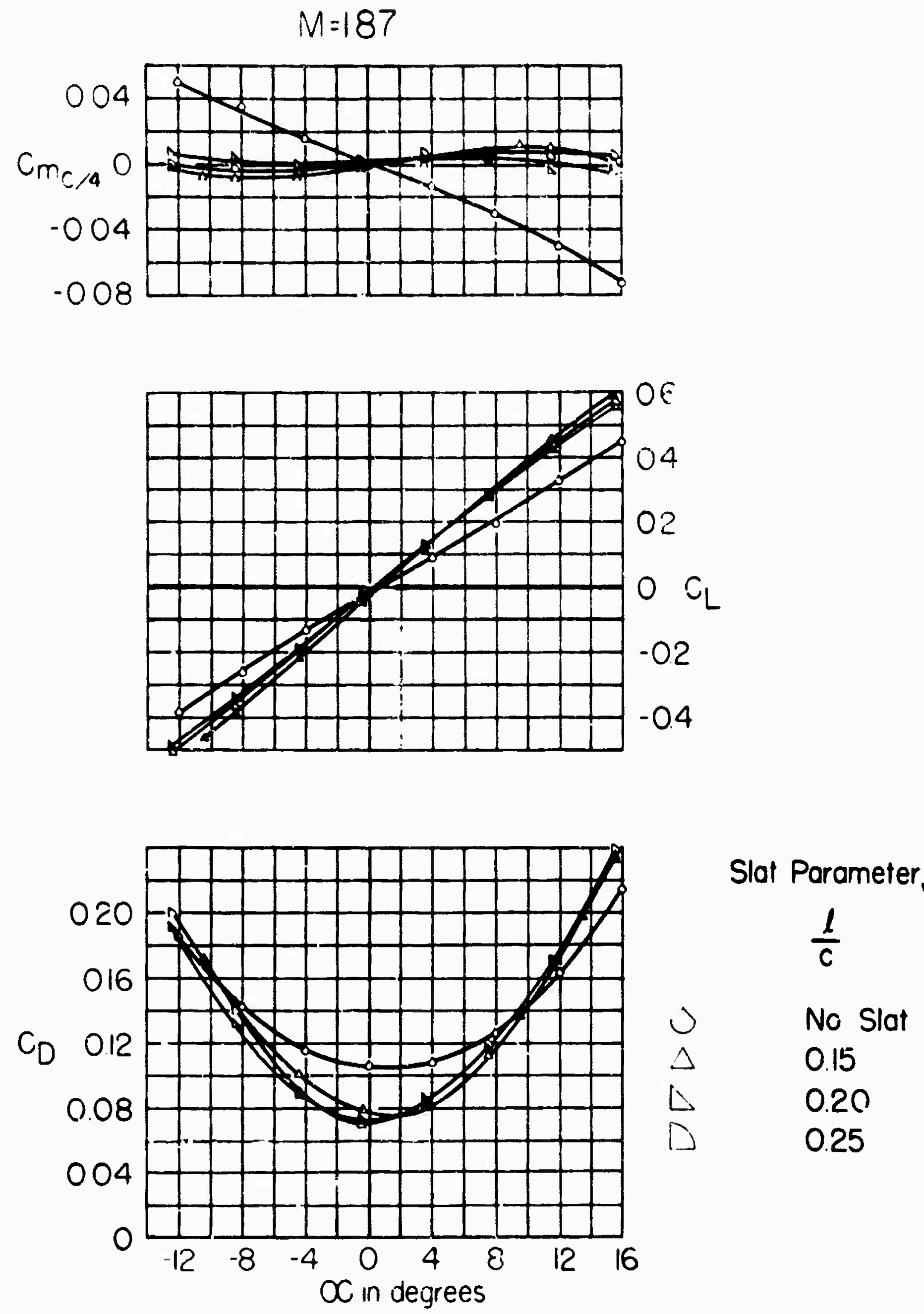

Figure 3 (Continued)

(c) Wedge With Long Plate Support; $(c_s/c) = 0.15$; $\beta = 6^{\circ}$; $\delta = 0^{\circ}$

M = 1.87

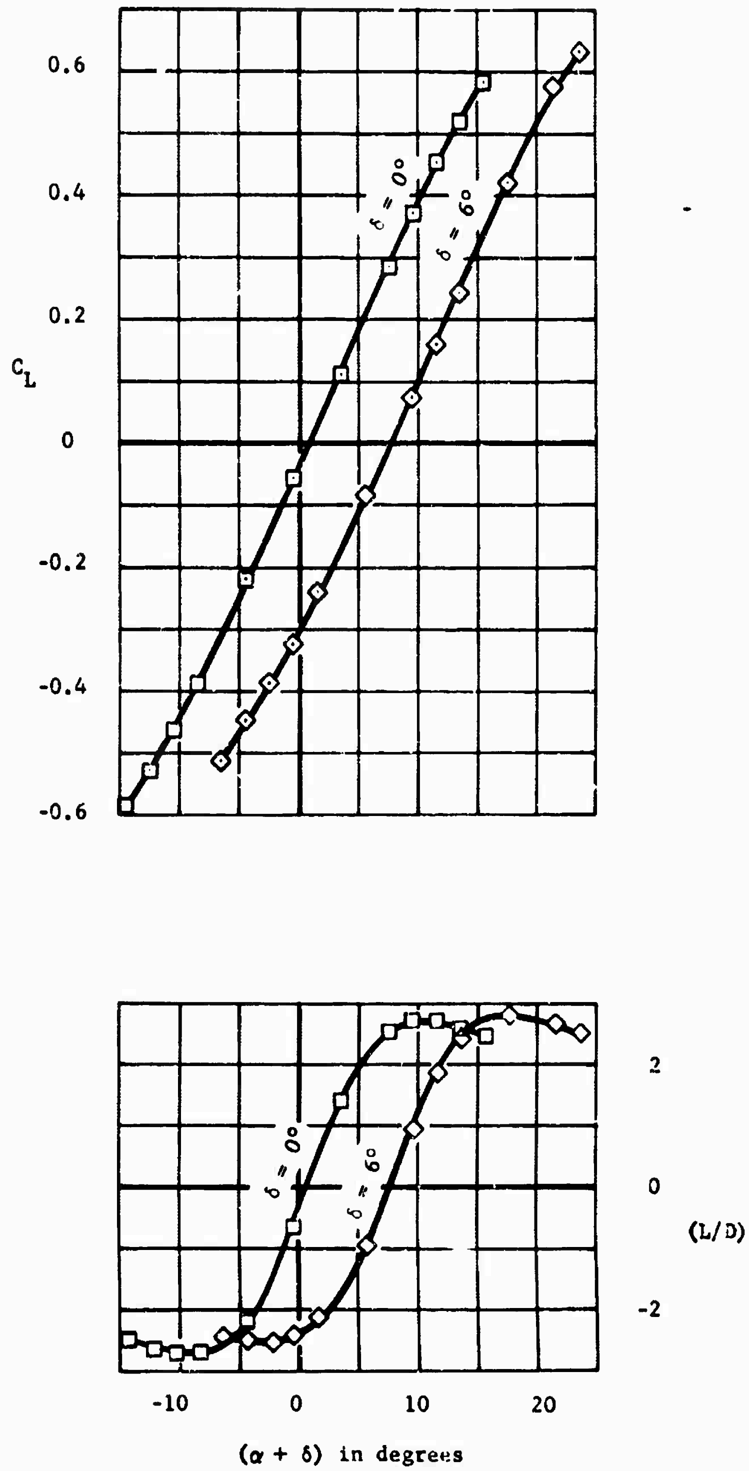

Figure 5 (Continued)

(b) Wedge With Long Plate Support. $c_s/c = 0.15$; $\beta = 6°$; $\ell/c = 0.15$

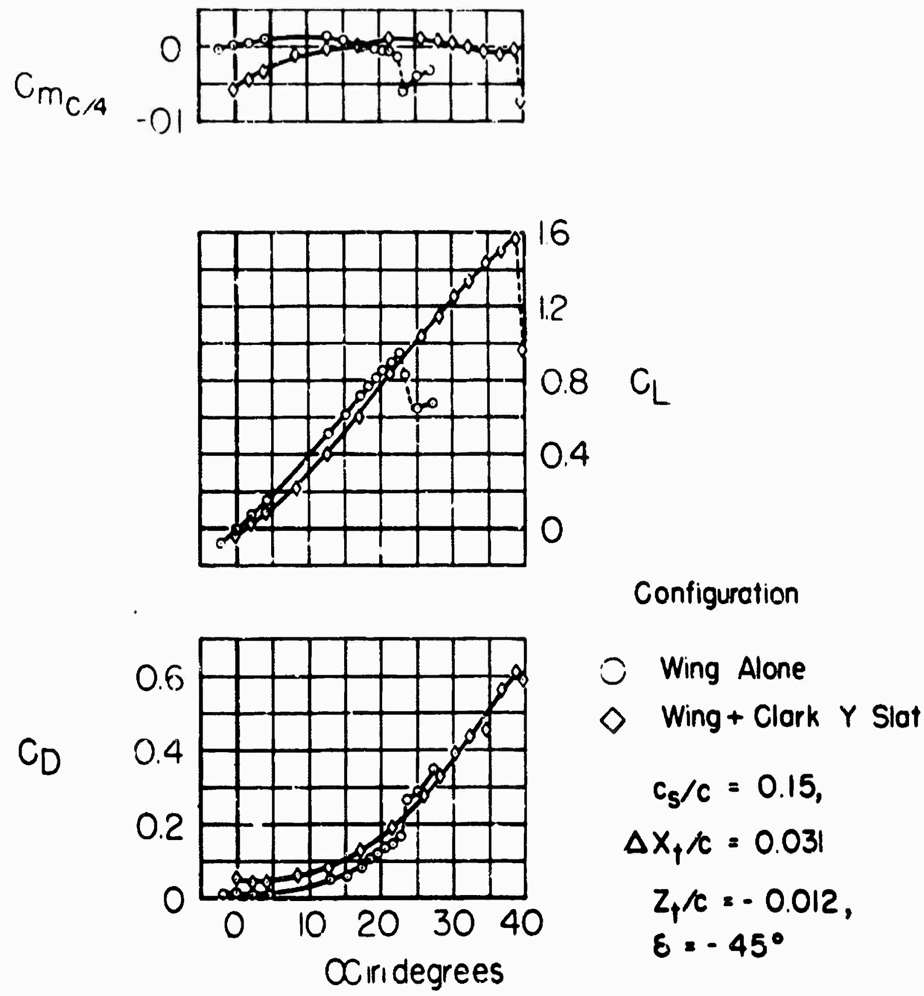

Figure 7 - Typical Low-Speed Longitudinal Characteristics of a Thick Wing With a Forward-Facing Clark Y Slat (M = 0.30)